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LA-UR-18-29195
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Title: Los Alamos National Laboratory Lessons Learned for Fiscal Year 2018: SAVY-4000 Lid Bar Stock Issue

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Intended for: Report

Issued: 2018-09-27

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**Los Alamos National Laboratory Lessons Learned for Fiscal Year 2018:**

# SAVY-4000 Lid Bar Stock Issue

Paul H. Smith, Jude Oka, Tristan Karns, Timothy Stone, Kirk Reeves, Jonathan Gigax,
Raj Vaidya, James Wendelberger, Nick Guadagnoli, Elizabeth Kelly,
Dakota Gregory, Robin Cunningham

## Discovery

During acceptance testing at Nuclear Filter Technologies (NFT) in May, 2018 of a batch of 150 SAVY-4000 containers (3 Qt), 89 containers were rejected due to failing and higher than normal helium leakage test results (see attachment NC#18-033). A total of 56 of those rejected failed the maximum allowed helium leakage rate criterion of 1.0E-05 std cc/sec specified in 55Y-002926 Rev. G, SAVY-4000 fabrication Specification. In addition, 33 containers were also rejected by the manufacturer with helium leakage rates measured between 1.0E-05 and 1.0E-06 std cc/sec (NFT NC# 18-033) because the containers were manufactured from the same lot of base material and the helium leakage rates were outside of the expected range. Upon discovery of the helium leakage test failures of the 3 Qt SAVY's, NFT pulled the inventory of containers that failed the helium leakage tests and performed a detailed inspection of the lid assemblies. Small voids were discovered by visual inspection on opposing sides of the lids.

## Analysis

One of the failing 3 Quart lids was sent to the manufacture of the bar stock (Valbruna, Slater Stainless, Inc.). The manufacture determined that the bar stock underwent and passed an ultrasonic test, and they also had Samuel Son & Co. Inc. prepare an etched specimen "in the transverse direction to observe the microstructure near the defect" for microscopic analysis (Figure 1). The memorandum (see attachments) from Valbruna (Memo to Michelle Parsons to Joe Vandiver, 6/26/18)) stated: "The defect falls within the acceptable size range for a ¼ FBH (6.4 mm) ultrasonic test. Additionally, this is a high machinability product with engineering inclusions to enhance machinability. These inclusions are aligned in the rolling direction. In this application, the transverse face is used as a containment surface. This product in this orientation may not be suitable for a pressure bearing surface or capable of passing a Hydrogen Leak test." Valbruna also offered to provide information on other products that might be more suitable for this application.

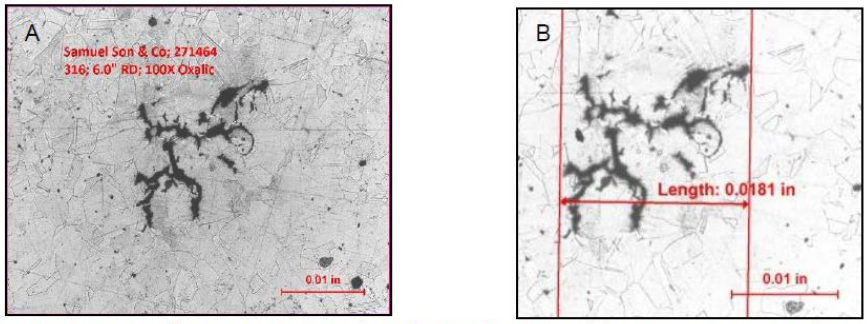


*Photo Series 1: A – Indication at 100X, Oxalic Etch; B – Indication with largest measurement of 0.0181"*

***Figure 1*** *Tranverse-section of a failed 3 Qt SAVY-4000 lid with a helium leakage rate >1E-05 std cc/sec.*

A cross-section of another failing lid was sent to LANL, cross-sectioned, and examined microscopically (Jonathan Gigax, MPA-CINT, Los Alamos National Laboratory). The cross-section revealed a void running through the minimum lid dimension (~2.6 mm thick) with a diameter ranging from ~0.02 to 0.1 mm (Figure 2). In addition to the cross-sectioning that was completed, a fluorescent dye penetration test was performed on a different 3 Qt lid with a helium leakage rate >1E-05 std cc/sec made from the same batch of bar stock (Figure 3), which indicated that there were several voids that penetrated the minimum lid dimension. Another SAVY lid (12 Qt) with a helium leakage rate of ~5E-06 std cc/sec was also found to have a through-wall penetration with the fluorescent dye test (Figure 4). This lid was made from a different batch of bar stock than the 3 Quart lids. A single lid from a recent batch of 8 Qt SAVY's that failed the helium leakage test at the manufacturer was also found to have voids on both sides of the lid. So, thus far, three batches of bar stock have been identified with through-wall penetrations.

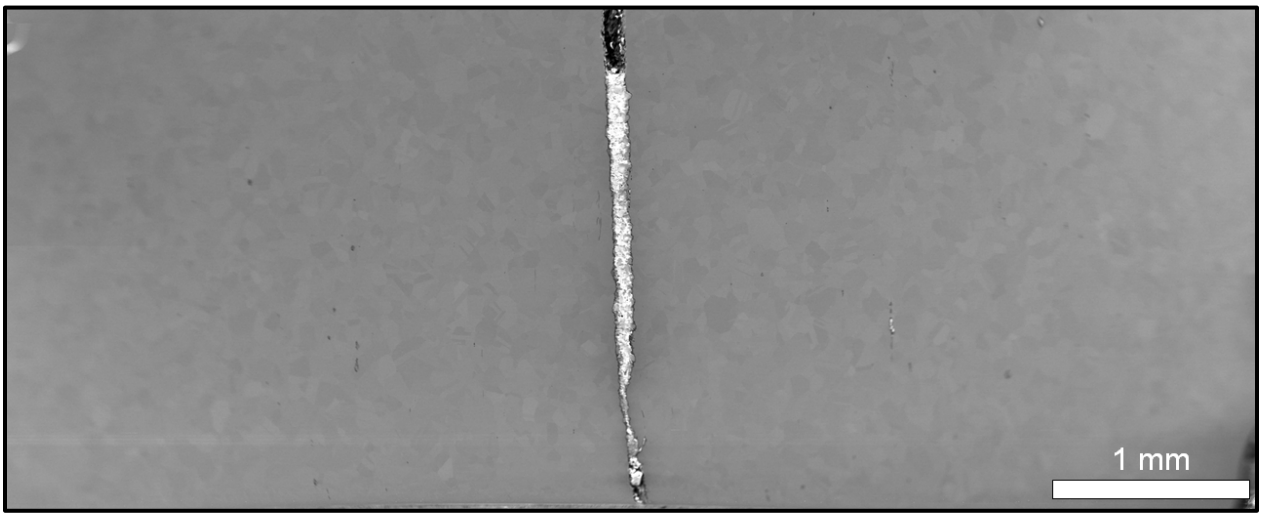


***Figure 2*** *Cross-section of a failed 3 Quart SAVY-4000 lid with a helium leakage rate >1E-05 std cc/sec. The through-wall void appears white due to a silica compound used in the polishing process during sample preparation.*

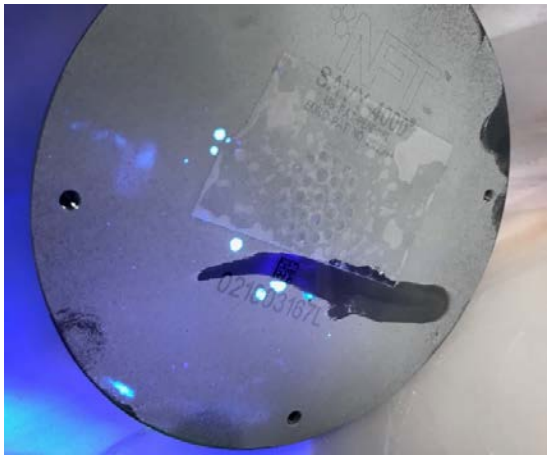

***Figure 3*** *Fluorescent dye penetrant testing of a failed 3 Quart SAVY-4000 lid with a helium leake rate >1E-05 std cc/sec showing more than one through-wall defects.*

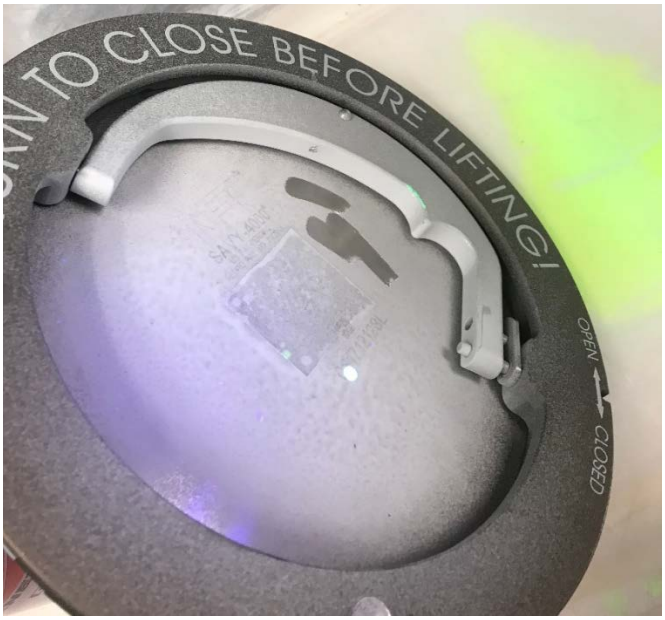


***Figure 4*** *Fluorescent dye penetrant testing of a 12 Quart SAVY-4000 lid with a helium leake rate of ~5E-06 std cc/sec showing a single through-wall defect.*

The current requirement (55Y-002926 Rev. G, SAVY-4000 fabrication Specification) states that the canister lid shall be fabricated from 316L stainless steel bar in accordance with ASTM A479/ASME SA-479. Through literature, it is well known that flaws running along the bar axis are fairly common, and manufacturing guidelines recommend against the use of bar stock for lids used in vacuum applications for this reason. *A User's Guide to Vacuum Technology by John O'Hanlon*, describes during the initial stages of mill production, when the metal begins to cool and solidify, the impurities contained within the metal will begin to distribute themselves at the top and center of the ingot. The portion with the most oxide and sulfide impurities is removed before rolling. Any remaining impurities are stretched into long narrow leak paths. The inclusions run in the direction of rolling. Based on this information, it is important to understand the final product's use and application in service to ensure that the correct raw stock is selected for fabrication. However, although the SAVY storage containers are tested under vacuum, they were not designed as a vacuum system because the container is filtered to allow hydrogen gas to escape during use. Furthermore, the minimum allowed container wall thickness of 0.5 mm (0.020 in) precludes the use of typical 1 atmosphere differential pressure helium leak test used for vacuum systems because this pressure differential can cause plastic deformation of the container walls. The manufacturing acceptance testing for the containers is performed at a differential pressure of ~0.1 atmospheres (>10 kPa) for this reason. The maximum normal operating pressure during use is 1 kPa for the quart-size containers and 2 kPa for the gallon-size containers.

**Extent of Condition**

The helium leakage test results for all previously manufactured SAVY containers were analyzed to understand the extent of condition of the bar stock issue. Figure 5 illustrates the results of this analysis for the 4,837 containers manufactured to date. The containers are sorted by the manufacture date and the container size, and this is expected to roughly correspond to unique bar stock lots. There are ~18 containers with helium leakage rates between 1.00E-06 and 1.00E-05 std atm/cc. The three lots with helium leakage rates >7.00E-06 are a batch of 1 Qt lids containers manufactured in July, 2012, a batch of 8 Qt containers manufactured in April, 2012, and batch of

12 Qt containers manufactured in March, 2017. One SAVY lid from the latter batch was shown to have a through-wall penetration with fluorescent dye penetration testing.

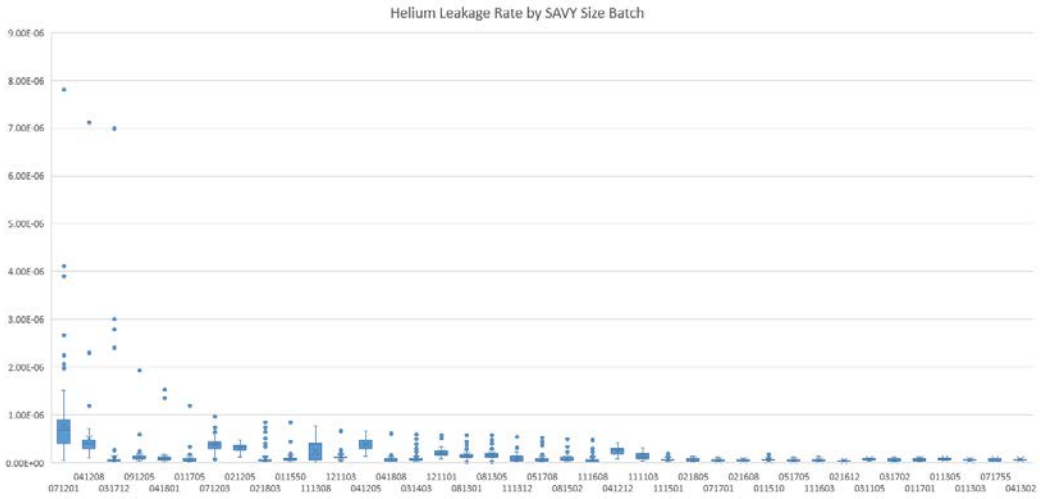


***Figure 5****. Box plots of helium leakage rates by SAVY size and manufacture date.*

A pareto analysis of the helium leakage test data shows that >99% of the SAVY containers have helium leakage rates <1E-07 std cc/sec (Figure 6).

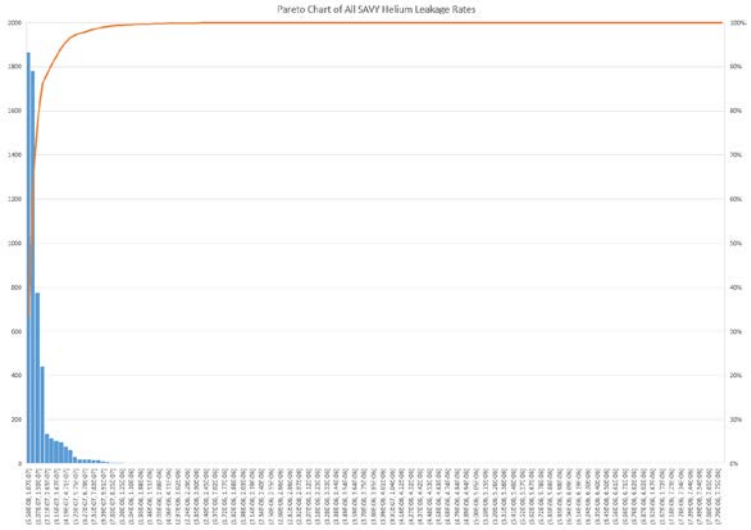


***Figure 6*** *Pareto chart of helium leakage rates for all SAVY containers manufactured to date.*

An error analysis of the helium leakage rate measurements was also performed and is illustrated in Figure 7. A total of 776 differences (all lids) between measurements performed at manufacturing (Vendor) and at Source Inspection (Baseline) were analyzed. The differences are very small, and in fact many are zeroes. There is one outlier, a high baseline measurement for container serial number 031712112L. Even including this value, the measurement error is very small (standard deviation of measurements = 1.1e-07). This can provide a basis for choosing the appropriate leakage rate criterion going forward. If we want to be 3 standard deviations below an acceptance limit (L) to account for measurement error, we will need to reject at L=3.3E-07, 6 standard deviations then use L= 6.6E-07. So if we are looking at limits in the >10-6 range, this does not have a major impact. This estimate of the standard deviation includes set up variability

as well as measurement variability, and thus provides a reasonably conservative estimate for the standard deviation.

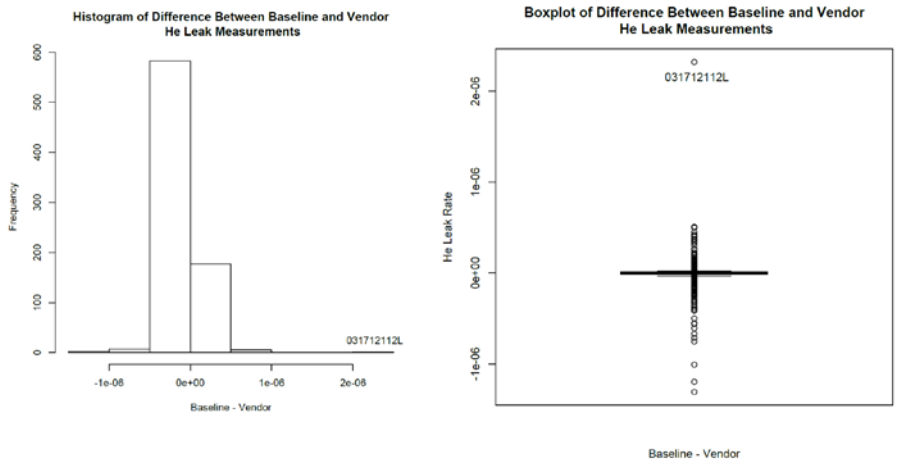


***Figure 7*** *Error analysis of helium leakage rate measurements. The Vendor measurements are the acceptance tests performed on 100% of the containers immediately after manufacturing. The Baseline measurements are the measurements performed on a 10% random sample during the QA source inspections.*

**Sulfur Content**

The microstructural and chemical analysis performed at LANL also revealed MnS "stringers" in the cross section of the failed 3 Qt SAVY lid (Figure 8). An analysis was also performed to evaluate the overall sulfur content of the stainless steel used to make the lids. This is published in LA-UR-18-29080, Data Visualization for Statistical Analysis and Discovery in Container Surface Characterization at the Nano-Scale and Micro-Scale, Wendelberger and Smith. This paper describes the analysis of three cross section images where MnS stringers were apparent in the lid cross section as dark "stringer-like" features. The stringer area ratio for the three stringer images was found to be 0.00034, 0.000894, and 0.00141 (Figure 9). Based on these ratios, the average, maximum, and minimum sulfur weight percentage values were estimated at 0.017, 0.027, and 0.006, all of which meet the specification of < 0.03% sulfur content.

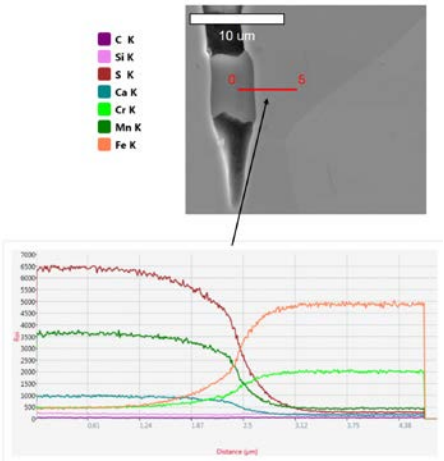


***Figure 8*** *Chemical and microstructural analysis of the surface of the cross-section of a failed 3 Qt SAVY lid showed that the stringers were primarily composed of MnS.*

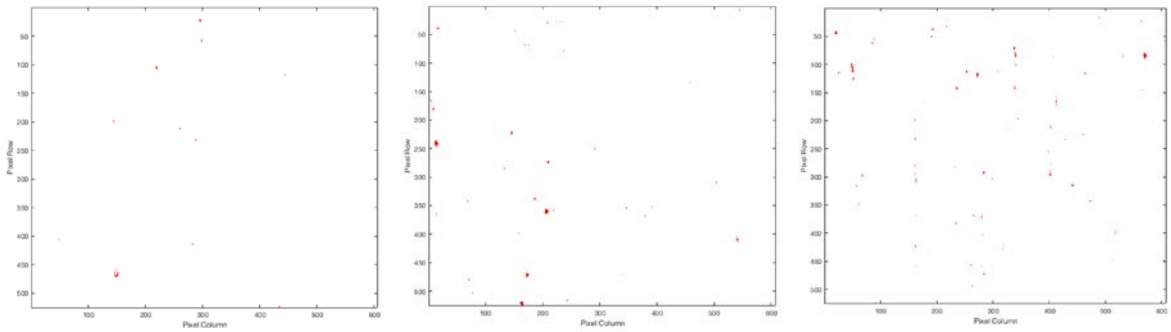

***Figure 9.*** *Three images of the cross sectional surface of one of the failing 3 Quart SAVY lids. The ratio of the dark spots/lines (representing the MnS stringers) to the total area image were used to confirm that the sulfur content was below the allowed specification for 316L SS and consistent with measurements made independently by the steel manufacturer and third party testers.*

**Mitigating the Problem**

It is important to note that all (100%) SAVYs as a containment system are acceptance tested with a helium leakage test at manufacturing, and therefore there is not a nonconformance in the population of containers that have been released for use. A specification change for future purchase orders will require that the lids be manufactured from 316L Stainless Steel per ASTM Standard A240 / A240M, The Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and general Applications (see Attachments, SDDR-NFT-453184-003). Furthermore, all surveillance containers evaluated to date passed the helium leakage tests at the time of surveillance. It is possible that there are some small, non-failing leak paths in the lids of containers that have been accepted for use. However, this is not expected to affect the container design life because: a) the diameter of the leak path is small enough to lead to passing the design qualification helium leakage test, b) third party testing of both chemical composition and mechanical properties confirm that the base material meets the 316L specification, c) gas phase corrosion, the most likely cause of failure observed thus far in surveillance, would most likely affect the thin container wall (0.5 mm) before it would corrode through the very small leak path in the lid for a distance of 2.1 mm, the minimum thickness of all SAVY lids. Finally, there is an additional factor of safety that stems from the fact that the maximum possible pressure differential for the containers during use is a factor of 5 to 10 less than the pressure differential of the helium leakage tests performed at manufacturing and during surveillance.

**Path Forward**

The path forward includes using flat plate stock instead of bar stock for SAVY's in future purchase orders. This will eliminate any inclusions running through the height of the lid which causes the potential leak paths. The manufacturer is also planning to rework the current containers from the population of 3 Qt lids with suspect bar stock and replace them with lids machined from plate stock. This will eliminate any questions or unforeseen problems that might arise from lids made from this questionable piece of bar stock. Rework includes sending the 3 Qt containers back to NFT to remove the lids while salvaging the remaining components, manufacturing new lids complying with the proposed SDDR-NFT-453184-003, installing new

lids into the salvaged containers and performing manufacturing acceptance testing and receipt inspection.

**Summary**

It was determined that the round bar manufacturing process leads to long grain flaws in lid base material. The stainless steel supplier has agreed that the selection of round bar is not appropriate for a pressure system. Although the application is not part of a pressure system, the design is being modified to require the use of flat plate moving forward. All previous containers have been leak tested and met the helium leakage criteria. Dye penetration testing with fluorescent dye on three SAVY lids and one Hagan lid shows promise as a method for determining if there are through-wall penetrations. A Subcontractor Deviation Disposition Request (SDDR) has been submitted and approved to make future lids in this Purchase Order from plate stock material. For future orders of SAVY containers, the manufacturing specification will be changed similarly. A change in the helium leakage rate pass/fail criterion is under consideration. An extent of condition review is in progress to use helium leakage test results (those close to failing, yet still passing) to identify containers accepted for use that could potentially have through-wall penetrations in the lids. An image analysis was performed on microscopic cross sections of a failing lid to estimate the % sulfur content. Results show that the sulfur quantity is within the 316L specification, which further confirms the original melt certification and 3rd party testing results. It should be noted that the current surveillance program is sufficient to identify any issues that may arise from the bar stock inclusions. The Surveillance plan is updated annually, and it will be modified as necessary to ensure that any issues associated with lids in the current population do not bring the container lifetime into question.

**Attachments**

NFT Nonconformance Report NC# 18-033

NCR 8442, Memorandum To: Michelle Parsons From: Joe Vandiver Subject: Samuel Son & Co. Inc. –HT#271464 -316 – 6.0” RD Claim – Inclusions in Machined Parts

Subcontractor Deviation Disposition Request, SDDR No.: SDDR-NFT-453184-003

# Nonconformance Report

# NC# 18-033

## Origination

Origination Complete ☑

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| NCR Date | 5/22/2018 | Total Qty | 137.00 | | | | |
| Customer | | | Customer Name | | | | |
| Vendor | | | Vendor Name | | | | |
| Status | Closed | Rejected Qty | 89.00 | Work Order | 7600-001 | Operation | He. Leak Testing |
| NC Type | In Process | Inspected Qty | 137.00 | Work Center | TESTING | Packlist | |
| Due Date | 6/1/2018 | Lot | N/A | Sales Order | | Reference | DR 180521 |
| Other Notes | | | | | | Manager | NGG |
| Item | 20130000 | | | Rev | 5 | Description | 3 Qt Assy - NucFil Dwg #20130000 |
| Ext Description | | | | | | | |
| Drawing # | 20130000 | Division | NFT | Department | Engineering | Close Date | 5/31/2018 |
| Priority | 1 | Warehouse | N/A | Class | ACTF | Serial | Various |
| Originated By | NGG | | Orig. Date | 5/31/2018 | | | |

### Tasks

| Description | Description of Non-Conformity | Status | Complete | Due Date | 5/31/2018 |
|---|---|---|---|---|---|
| Briefly describe the apparent non-conformity:<br><br>Requirement: Per the SAVY-4000 Fabrication Specification, 55Y-002926 Rev. G, Section 3.7.B.2, the maximum helium leak rate shall be 1.0E-05 std cc/sec @ 10kPa.<br><br>Obervations: Of the tested containers, 56-ea. exhibited leak rates in excess of the requirement. Additionally, of the remaining acceptable assemblies, there were 33-ea. assemblies which yielded acceptable leak rates in the 10^-6 range. | | | | | |
| User: | NGG | Complete Date: | 5/31/2018 | | |

## Investigation

Investigation Complete ☑

| | | | | | |
|---|---|---|---|---|---|
| Origin | Work Center | Origin Cause | ACTF | CPA No | |
| Origin Ref | TESTING | Origin Category | Helium Leak Test | | |
| Origin Ref Name | | | | | |
| Investigated By | NGG | Investigation Date | 5/31/2018 | | |

### Tasks

| Description | Significance | Status | Complete | Due Date | 5/31/2018 |
|---|---|---|---|---|---|
| Is this condition found to be significant? (Y/N) No<br><br>Is this condition found to be recurrent ? (Y & No. or N) No<br><br>If either answer is yes initiate a linked Corrective Action | | | | | |
| User: | NGG | Complete Date: | 5/31/2018 | | |

# Nonconformance Report NC# 18-033

| Description | Cause | Status | Complete | Due Date | 5/31/2018 |
|---|---|---|---|---|---|

If the investigation did not generate a report describe the investigation here. (Include objective evidence)

Upon discovery of 3QT SAVY-4000 Assemblies failing Helium Leak Testing, NFT began to investigate the potential cause for the failures. A complete 3QT SAVY-4000 Assembly (S/N: 021803151 from WT 7500-001) was pulled from inventory and tested to confirm that the Leak Testing set-up was correct. Once the test system set-up was confirmed to be correct, NFT utilized this container as a reference standard to begin to evaluate various components of the assembly to identify the cause of the failures.

The Lid and O-Ring of the reference standard container was mated with several known Weldmaps that failed Helium Leak Testing. The results of testing these combinations yielded acceptable leak rates. Additionally, NFT performed tracer probe leak tests on several of the Weldmaps by themselves and no leaks were identified. This allowed NFT to rule out any potential issues with the weld between the Locking Collar and the Canister Body.

Next, NFT assembled several known Lids that failed Helium Leak Testing with the reference standard Weldmap. The results yielded failing leak rates in excess of 1.0E-05 std cc/sec @ 10kPa. Initially, the O-Ring originally mated with the failing assembly was utilized for these tests. In order to rule out any issue with the O-Ring, NFT utilized the reference standard O-Ring on several of these combinations and the same failing leak rates were observed.

The results of these trials indicated that the issue resided with the Lid. After this discovery, NFT performed a tracer probe leak test on one of the failing Lids and found an indication of a leak through the Lid. In order to validate the suspect location, the indication was plugged with clay and a tracer probe again passed over the area. After placing the clay over the suspect location the indicated leak disappeared, thus confirming a leak path.

NFT then inspected the suspect location at 30X magnification and discovered a void that appeared to go all the way through the material. NFT continued to inspect all failing lids under magnification and discovered similar voids and inclusions.

What is the determined cause of this nonconformance.

The suspected cause for the nonconforming leak rates is due to the Lid material containing voids and inclusions which created direct leak paths through the material.

| User: | NGG | Complete Date: | 5/31/2018 | |
|---|---|---|---|---|

## Disposition

Disposition Complete ☑

| Disposition | Reject / Discard | Scrap Qty | 89 | Return Qty | |
|---|---|---|---|---|---|
| | | Rework Qty | | Use As Is Qty | |
| Disposition By | CJM | Disposition Date | 5/31/2018 | | |

### Tasks

| Description | Remediation | Status | Complete | Due Date | 5/31/2018 |
|---|---|---|---|---|---|

Reject / Discard:

The 3QT Lids that exhibited failing leak rates as well as the Lids which exhibited leak rates in the 10^-6 range shall be discarded. The serial numbers of Lids that are to be discarded can be identified on the Helium Leak Test Report. In total, 89-ea. Lids shall be discarded.

The Lids shall be disassembled from its associated Weldmap. The O-Ring shall be removed from the Lid, bagged, labeled and placed into its mating weldmap. The Locking Ring shall be disassembled from the Lid by unthreading the Shoulder Bolts. The Handle shall remain assembled to the Locking Ring. Once the Locking Ring and Lid have been disassembled, the Locking Ring shall be placed with its mating Weldmap. All sub-assemblies and Shoulder Bolts shall be returned to inventory until the time when another batch of Lids are available for re-assembly. Inherently, due to the mechanical assembly of the Filter Cup, Media, and Hydrophobic Membrane, these components will also be scrapped when the Lids are discarded.

| User: | NGG | Complete Date: | 5/31/2018 | |
|---|---|---|---|---|

| Description | Recurrence | Status | Complete | Due Date | 5/31/2018 |
|---|---|---|---|---|---|

A total of 4-ea. Lids were sent out for analysis. Two Lids were sent to the Mill Laboratory (Valbruna in California) for evaluation, and two Lids were sent to LANL for evaluation. Based on the results of the evaluations, NFT will determine an appropriate path forward regarding procurement of raw material for SAVY Lids. In addition, NFT will continue to investigate feasable methods to identify these types of voids and inclusions on future batches of Lid material.

Additional Lid material will not be procured until the evaluations are complete and a clear path forward has been determined.

| User: | NGG | Complete Date: | 5/31/2018 | |
|---|---|---|---|---|

| Description | Completion | Status | Complete | Due Date | 5/31/2018 |
|---|---|---|---|---|---|
| When the required actions have been completed Quality Management will record that by closing this task.<br><br>Completed - CJM<br>05/31/2018 14:42 | | | | | |
| User: | CJM | Complete Date: | 5/31/2018 | | |

| Description | 3rd Party Approval | Status | Complete | Due Date | 5/31/2018 |
|---|---|---|---|---|---|
| If 3rd Party Approval is required record the individuals name who approved the disposition, and stamp the entry.<br><br>3rd Party Name: Not Required (Disposition is Reject / Discard)<br><br>Recorded By: Nick Guadagnoli 05-31-2018 | | | | | |
| User: | NGG | Complete Date: | 5/31/2018 | | |

## Verification

Verification Complete ☑

| Verified By | CJM | Verification Date | 5/31/2018 | |
|---|---|---|---|---|

### Tasks

| Description | Physical Check | Status | Complete | Due Date | |
|---|---|---|---|---|---|
| Verify that all dispositions have been completed<br><br>If any variance from the recorded methods or amounts occurred describe it below.<br><br>Document Control has verified all records are complete and filed | | | | | |
| User: | JAD | Complete Date: | 5/31/2018 | | |

| Description | QM Approval | Status | Complete | Due Date | 5/31/2018 |
|---|---|---|---|---|---|
| Approved - CJM<br>05/31/2018 14:56 | | | | | |
| User: | CJM | Complete Date: | 5/31/2018 | | |

## Attachments

| Type | Path | Description |
|---|---|---|

VALBRUNA
SLATER STAINLESS, INC.

NCR 8442

6/26/2018

To: Michelle Parsons
From: Joe Vandiver
Subject: Samuel Son & Co. Inc. – HT#271464 – 316 – 6.0" RD
Claim – Inclusions in Machined Parts

Dear Michelle,

**Overview**

The customer submitted two machined samples from HT#271464 for evaluation. The claim stated there are inclusions in machined parts.

**Evaluation**

The routing for the material was reviewed. It was found the material underwent a ¼ FBH (6.4 mm) ultrasonic test. An etched specimen was prepared in the transverse direction to observe the microstructure near the defect, Photo Series 1.

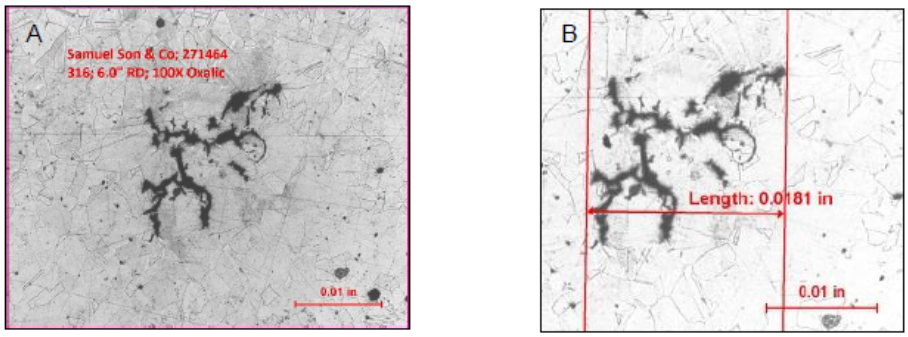


*Photo Series 1: A – Indication at 100X, Oxalic Etch; B – Indication with largest measurement of 0.0181"*

**Discussion**

This product was produced as standard air melt stock. The material was not purchased to any ultrasonic test criteria. The test criteria used was an internal standard for material of this size and grade. The defect falls within the acceptable size range for a ¼ FBH (6.4 mm) ultrasonic test. Additionally, this is a high machinability product with engineering inclusions to enhance machinability. These inclusions are aligned in the rolling direction. In this application, the transverse face is used as a containment surface. This product in this orientation may not be suitable for a pressure bearing surface or capable of passing a Hydrogen Leak test.

**Conclusion**

Based on our analysis, the claim is not justified. We hope this information is useful to you. Valbruna offers another product more suitable for this application. Please feel free to contact us with any further questions.

Best Regards,

| | | |
|---|---|---|
| Joe Vandiver | Natalie Mowery | Annmarie Asiala |
| Quality, VSSI | Quality, VSSI | Quality Manager, VSSI |

2400 TAYLOR STREET WEST • PO BOX 630
FORT WAYNE IN USA 46802
PHONE 260.434.2800 • FAX 260.434.2801

Los Alamos NATIONAL LABORATORY EST. 1943

**Conduct of Engineering**
**Subcontractor Deviation Disposition Request**

By LANS upon receipt: SDDR No.: SDDR-NFT-453184-003 Date Received: 08/07/18

Instructions to Subcontractor:

1. Notify LANS Subcontract Technical Representative (STR), or LANS Subcontract Administrator (SA) if no STR, within 5 working days after identification or detection of proposed deviation.
2. Instructions on reverse provide additional direction for completing and processing this form.
3. Attach additional supporting information whenever necessary.
4. Submit completed form by email to STR, or SA if no STR, as soon as possible.
5. Copy of completed form will be returned to Subcontractor after LANS evaluation and disposition.

Form available at http://engstandards.lanl.gov/

| **1.0 SUBCONTRACTOR'S REQUEST FOR DEVIATION FROM CONTRACTUAL REQUIREMENTS** | | |
|---|---|---|
| 1.1 Subcontractor's Document No.: 55Y-002926 Rev. G | 1.2 Date Submitted: 08-02-2018 | |
| 1.3 Subcontractor Information (Name, Address, Point of Contact, and Telephone Number)<br>NFT, Inc. 4653 Table Mountain Drive Golden, CO 80403 Nick Guadagnoli 303-384-9785 x254 | | |
| 1.4 Subcontractor Order Number:<br>453184 | Subcontractor Item No:<br>Line Item 11<br>P/N 20130200 | Item Name:<br>SAVY-4000 3QT Lid |
| 1.5 LANS Subcontract No.:<br><br>453184 | LANS Subcontract Administrator<br><br>Marty Stunkel | LANS Subcontract Technical Representative:<br><br>LANL Container Management Team:<br>Robin Cunningham – FLM<br>Tim Stone, Paul Smith, Vera Aguino |
| 1.6 Date Deviation Detected:<br>05-17-2018 | Detection Method: NDT Helium Leak Testing of 3QT SAVY-4000 Assemblies | |
| 1.7 Previous SDDR submittals for same or similar issue: N/A | | |
| 1.8 LANS STR or SA Notified: Email (5/17/18) / Conference Call (5/18/18) LANL Container Management Team | | |
| 1.9 Description:<br>During production, the SAVY-4000 Assembly is subjected to Helium Leak Testing to ensure the containment boundary total leak rate is less than 1.0E-05 std cc/sec at 10kPa. The 3QT SAVY-4000 Assemblies being produced to satisfy Subcontract Number 453184 Line Item 11 exhibited an abnormally high failure rate during Helium Leak Testing. Of the 137 tested containers, 56-ea. exhibited leak rates in excess of the acceptance requirement. Additionally, of the remaining acceptable assemblies there were 33-ea. assemblies which yielded acceptable leak rates in the 10^-6 range.<br><br>Upon discovery of 3QT SAVY-4000 Assemblies failing Helium Leak Testing, NFT began to investigate the potential cause for the failures. A complete 3QT SAVY-4000 Assembly (S/N: 021803151) was pulled from inventory and tested to confirm that the Leak Testing set-up was correct. Once the test system set-up was confirmed to be correct, NFT utilized this container as a reference standard to begin to evaluate various components of the assembly to identify the cause of the failures. | | |



VTA, Z#102320, 8/10/18

The Lid and O-Ring of the reference standard container was mated with several known Weldmaps that failed Helium Leak Testing. The results of testing these combinations yielded acceptable leak rates. Additionally, NFT performed tracer probe leak tests on several of the Weldmaps by themselves and no leaks were identified. This allowed NFT to rule out any potential issues with the weld between the Locking Collar and the Canister Body.

Next, NFT assembled several known Lids that failed Helium Leak Testing with the reference standard Weldmap. The results yielded failing leak rates in excess of 1.0E-05 std cc/sec @ 10kPa. Initially, the O-Ring originally mated with the failing assembly was utilized for these tests. In order to rule out any issue with the O-Ring, NFT utilized the reference standard O-Ring on several of these combinations and the same failing leak rates were observed.

The results of these trials indicated that the issue resided with the Lid. After this discovery, NFT performed a tracer probe leak test on one of the failing Lids and found an indication of a leak through the Lid. In order to validate the suspect location, the indication was plugged with clay and a tracer probe again passed over the area. After placing the clay over the suspect location the indicated leak disappeared, thus confirming a leak path.

NFT then inspected the suspect location at 30X magnification and discovered a void that appeared to go all the way through the material. NFT continued to inspect all failing lids under magnification and discovered similar voids and inclusions.

In addition to in-house investigations conducted by NFT, samples of the failing lids were sent to Valbruna Slater Stainless, Inc. (Mill which produced the suspect heat of material). Valbruna's investigation acknowledged that the product contains engineered inclusions to enhance the machinability of the material and that the inclusions are aligned in the direction of rolling. Furthermore, they concluded that the engineered inclusions fall within the acceptable limits of the product, and that the product, as it is used in the SAVY-4000 assembly, may not be suitable for pressure bearing, leak tight surfaces.

Based on the investigation conducted it is suspected that the Lid material contained voids and inclusions that created direct leak paths through the material which in turn caused the nonconforming leak rates.

| 1.10 Cost Impact of proposed disposition: | 1.11 Schedule Impact of proposed disposition: |
|---|---|
| $0 | Delivery estimated at 3 months (mid-November) after approval of this SDDR |

1.12 Proposed Action and Technical Justification:

NFT proposes that the subject lids be manufactured from 316L Stainless Steel per ASTM Standard A240 / A240M, The Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and general Applications.

This grade and type of stainless steel is more ideally suited for providing a leak tight Lid when compared to the current material type and grade required in the SAVY-4000 Fabrication Specification, 55Y-002926 Revision G. The current requirement states that the canister lid shall be fabricated from 316L stainless steel bar in accordance with ASTM A479 / ASME SA-479. Although both types of material and specifications control the material properties to ensure high grade corrosion resistant stainless steel, the biggest difference lies in how the formed metal is produced.

An excerpt from, *A User's Guide to Vacuum Technology by John O'Hanlon,* describes the general process of metal manutacturing. During the initial stages of mill production, when the metal begins to cool and solidify, the impurities contained within the metal will begin to distribute themselves at the top and center of the ingot. The portion with the most oxide and sulfide impurities is removed before rolling. Any remaining impurities are stretched into long narrow leak paths. The inclusions run in the direction of rolling. Based on this information, it is important to understand the final product's use and application in service to ensure that the correct raw stock is selected for fabrication.

With respect to round bar, the inclusions and potential leak paths will tend to run through the axis of the material. NFT's current manufacturing process cuts the round bar into 'blanks' (usually, 1/2" – 5/8" thick; machined to 0.100" thick in places when finished) and machines the part from this 'blank'. As observed in the 3QT SAVY-4000 Lids, this process could yield leak paths through the material due to the inclusions.

Alternatively, inclusions within plate will tend to run through the axis of the thickness of the material, providing for a lower probability of a direct leak path through the Lid. NFT's intended manufacturing process would include waterjet cutting round discs from 5/8" thick plate at a specified diameter which would then be machined into finished lids, inherently reducing the chance of a leak path through the Lid.

In addition to evaluating the change from round bar to plate stock, NFT also investigated other types of stock materials which would potentially be suitable for the service conditions of the SAVY Lids. Another type of round bar surfaced through discussions with NFT's metal distributor. This round bar is different from ASTM A479 round bar in the sense that the material undergoes an additional process under a vacuum environment (a.k.a. vacuum re-melt) which further reduces the amount of impurities in the raw stock. ASTM A479 round bar is produced as standard air-melt stock, increasing the amount of impurities when compared to the vacuum re-melt material. Although a potential option, this product is not feasible for use in SAVY-4000 Lid manufacturing due to the significant price per pound increase as well as the commercial availability of this material. Material of this type is typically produced as custom mill runs which would require a significant financial investment as well as increased lead time to delivery (on average, 22 weeks ARO). For these reasons, NFT eliminated the possibility of using this type of material.

Currently, NFT evaluates the chemical and mechanical properties of the raw stock via sampling and 3rd party analysis on a heat by heat basis. The acceptance criteria for chemical composition shall be within the limits of ASTM A479, Table 1 UNS designation S31603 with allowable tolerances provided in ASTM A484. Mechanical properties evaluated are Yield Strength (by 0.2% offset method) and Elongation. Yield Strength shall be ≥ 25ksi & Elongation shall be ≥30% per ASTM A479.

Utilizing 316L stainless steel plate per ASTM A240 / A240M for the fabrication of 3QT Lids offers equivalent material properties to that of ASTM A479.

| ASTM A479 Properties: | ASTM A240 / 240M Properties: |
|---|---|
| Carbon: 0.03% Max | Carbon: 0.03% Max |
| Manganese: 2.00% Max | Manganese: 2.00% Max |
| Phosphorus: 0.045% Max | Phosphorus: 0.045% Max |
| Sulfur: 0.03% Max | Sulfur: 0.03% Max |
| Silicon: 1.00% Max | Silicon: 1.00% Max |
| Chromium: 16.0% - 18.0% | Chromium: 16.0% - 18.0% |
| Nickel: 10.0% - 14.0% | Nickel: 10.0% - 14.0% |
| Molybdenum: 2.00% - 3.00% | Molybdenum: 2.00% - 3.00% |
| | Nitrogen: 0.10% Max |
| Tensile Strength: 70,000psi Min | Tensile Strength: 70,000psi Min |
| Yield Strength (0.2% Offset): 25,000psi Min | Yield Strength (0.2% Offset): 25,000psi Min |
| Elongation: 30% Min | Elongation: 40% Min |

To the best of NFT's knowledge, a change in raw stock for the fabrication of SAVY-4000 Lids would not have any adverse effects of the SAVY-4000 during service nor would it impact any of the safety analysis requirements of the SAVY-4000 package. Furthermore, the Lids that were used during the design qualification testing of the SAVY-4000 product line were fabricated from material that had Elongation properties greater than 40%. Therefore, NFT proposes that 316L stainless steel plate per ASTM A240 / 240M be used for the fabrication of SAVY-4000 Lids.

1.13 Associated Subcontractor Document Change(s):
NFT Drawing, 20130200 Revision 5, Material Call-Out

1.14 Subcontractor's Authorized Representative: *(Name, Title, Telephone Number, and Date)*

*Nick Guadagnoli, NFT Sr. Engineer, 303-384-9785 x254* *08-02-2018*

**2.0 LANS EVALUATION AND DISPOSITION**

| | | | | |
|---|---|---|---|---|
| 2.1 Project ID: PO 453184 | Project Title: 3Q SAVY Lids | | | |
| 2.2 Affected SSC Management Level: | ☒ ML-1 | ☐ ML-2 | ☐ ML-3 | ☐ ML-4 |
| 2.3 Affected SSC Functional Classification | ☒ SC | ☒ SS | ☐ DID | ☐ NS |
| 2.4 Proposed Action | ☒ Accepted | | ☐ Rejected | |

2.5 LANL Actions:
Accept and Approve NFT's proposed change in the Lid material from "Round Bar" to "Plate Stock".

| | | | | | |
|---|---|---|---|---|---|
| ☐ USQD/ USID Required | USQD/USID No.: | | Other Subcontractors Affected | ☐ Yes | ☒ No |
| ☒ Drawing Change | ☐ LANL | ☒ Subcontractor | ☐ Price Adjustment | ☐ Yes | ☒ No |
| ☐ Specification Change | ☐ LANL | ☐ Subcontractor | ☐ Baseline Change | ☐ Yes | ☒ No |
| ☐ Other: | | | | | |

2.6 Disposition Statement:
Accept and Approve NFT's proposed change in the Lid material from "Round Bar" to "Plate Stock".

2.7 Technical Subject Matter Expert (TSME): *(Name, Z Number, Organization, Signature and Date)*
Tristan Karns, Z281087, NPI-9
Tristan Karns
Digitally signed by Tristan Karns
DN: c=US, o=U.S. Government, ou=Department of Energy, ou=Los Alamos National Laboratory, ou=People, serialNumber=281087, cn=Tristan Karns
Date: 2018.08.07 09:38:42 -06'00'

2.8 Design Authority Representative (DAR): *(Name, Z Number, Organization, Signature and Date)*
Kirk Reeves, Z237087, NPI-9
KIRK REEVES (Affiliate)
Digitally signed by KIRK REEVES (Affiliate)
DN: c=US, o=U.S. Government, ou=Department of Energy, 0.9.2342.19200300.100.1.1=89001002915453, cn=KIRK REEVES (Affiliate)
Date: 2018.08.07 09:43:50 -06'00'

2.9 Quality Subject Matter Expert (QSME): *(Name, Z Number, Organization, Signature and Date)*
Dakota Gregory, Z306883, QPA-IQ
Dakota James Gregory
Digitally signed by Dakota James Gregory
DN: c=US, o=U.S. Government, ou=Department of Energy, ou=Los Alamos National Laboratory, ou=People, serialNumber=306883, cn=Dakota James Gregory
Date: 2018.08.08 05:54:15 -06'00'

2.10 Project Engineer: *(Name, Z Number, Organization, Signature and Date)*
Diane Spengler, Z148648, ES-55
DIANE SPENGLER (Affiliate)
Digitally signed by DIANE SPENGLER (Affiliate)
Date: 2018.08.08 09:02:03 -06'00'

2.11 Subcontract Technical Representative (STR): *(Name, Z Number, Organization, Signature and Date)*
Timothy Stone, Z093414, NPI-9
Timothy Amos Stone
Digitally signed by Timothy Amos Stone
DN: c=US, o=U.S. Government, ou=Department of Energy, ou=Los Alamos National Laboratory, ou=People, serialNumber=093414, cn=Timothy Amos Stone
Date: 2018.08.07 09:46:30 -06'00'

2.12 LANS Subcontract Administrator: *(Name, Z Number, Organization, Signature and Date)*
Martin Stunkel, Z231743, ASM-PUR
8/9/18